

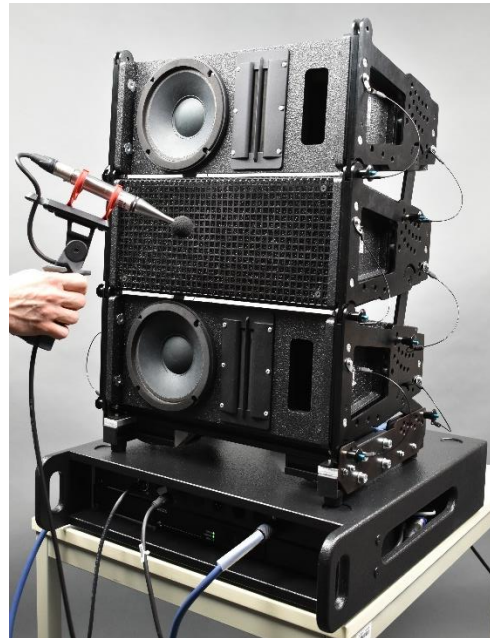
Efficient, Mobile Quality Assurance of PA Speakers

AN79b

Application Note for the KLIPPEL QC Stand-alone System (Document Revision 1.3)

FEATURES

- Efficient and objective quality control
- Reliable detection of severe driver, enclosure, and electronics defects
- Fast and simple to set up and operate
- Mobile hardware setup based on QC Stand-alone and *Dante*[®] smart amplifier
- Robust through relative metrics and universal limits
- Insensitive toward microphone placement and ambient noise
- Suitable for all passive, active and self-powered topologies
- Price-efficient, scalable



APPLICATION

- Mobile loudspeakers of any size: line arrays, near-field & stage monitors, sub-woofer, full-range speakers
- Event and rental business
- Service station and refurbishment

DESCRIPTION

In commercial, public events the audience expects nothing but a flawless performance. Especially in concerts, defects in the most stressed component of the audio system - the loudspeakers - can impair the experience drastically. Back in stock, simple listening tests are widely used for inspection, being inaccurate, highly subjective and stressful for the operator. Critical sound pressure levels cannot be used at all to avoid hearing damage. Consequently, defects may go unnoticed resulting in a failure in the worst moment, in front of the audience, where no solution is available.

In order to overcome these problems, *AN79a* suggests objective, electro-acoustic testing using the KLIPPEL QC System based on KLIPPEL Analyzer, switchers, microphone arrays and a controlled test environment for best sensitivity and reproducibility, comparable to manufacturer end-of-line testing.

However, in contrast to this full-featured test concept, the present document suggests a scaled-down, price-efficient approach for smaller companies, secondary test sites and mobile test setups. Together with *Tech Note 17 - Setting up Dante & Powersoft Mezzo for QC Stand-alone*, this concept relies on a minimal set of hardware components using a *Dante*[®] compatible audio-over-IP amplifier with integrated voltage and current sensors as the main test frontend operated with QC Stand-alone software version. It also suggests a simple and effective test strategy that relies on a small set of single values, and relative metrics that can be tested against universal pass/fail and grade limits.

The main step-by-step guide addresses a standard setup that does not incorporate a test box or separate measurement-room. However, a semi-open test box can be added to provide more controlled and

reproducible conditions and a limited amount of attenuation at mid and high frequencies to reduce both ambient noise disturbance as well as peak SPL contamination for the operator and the surrounding.

The suggested strategies assure that your speakers always return to stock fully functional. Carrying out the tests does not require trained specialists and can be done by any staff member. Following this guideline helps you maintaining a professional quality level of your audio systems providing a major advantage over your competition and a base for long-term trust between you and your clients.

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1 Overview

1.1 How to Use this Application Note

Scenarios	<p>This guide focuses on an efficient testing approach to be used in a typical real-life test environment without dedicated test stand and sound insulation. However, for better robustness against noise disturbance and reduction of emitted SPL during the test, a separate (untreated) room or a simple test box can be useful.</p> <p>Therefore, three different setup scenarios are suggested</p> <ul style="list-style-type: none"> • Basic: speaker on floor/table, hand-held microphone • Intermediate: test dolly, microphone stand • Pro: open test box with fixed microphone position
Contents	<p>The main aspects covered in this application note are:</p> <ul style="list-style-type: none"> • preparing necessary equipment/software • creating and customizing test sequences • creating limits • test operation • diagnostics <p>which can be divided into three phases:</p> <ol style="list-style-type: none"> 1) initial setup 2) test sequence setup 3) testing <p>The initial setup and preparation should be conducted by a qualified person with sufficient technical understanding while the actual testing can be operated by any staff member after short training.</p> <p>Follow the Quick Start Guide for step-by-step instructions.</p>

1.2 Test Objects

The application focuses on rental houses and their sound equipment, in particular loudspeakers of all shapes and forms such as

- Subwoofer
- Mid-high and full-range speaker
- Line array
- Column line array
- Stage monitor



All of the above can be acoustically measured in both self-powered and passive topology. An electrical measurement is only applicable for passive loudspeakers.

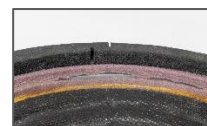
1.3 Results

Defects

The test methods suggested in this application note mainly focus on detecting loudspeaker defects or defect symptoms reliably. Here is a selection:

- No functional output, overload (open loop, short circuit, electronics failure)
- No output of LF, MF, or HF channel
- Abnormal noise and distortion (rub & buzz, loose particles)
- Abnormal air noise (enclosure, driver, port)
- Dropouts (electronics, connectors)
- Limited power handling (insufficient SPL, too much distortion)
- Parameters of spec (tuning frequency, rated impedance)
- Bad voice coil or suspension centering

Find more information in the sections [Typical Defects](#) and [Interpreting Results](#).



Acoustical Parameters

The following results are based on measurement with a continuous log sweep (chirp) or a single tone:

- **Average level**
 - Sensitivity and maximum SPL
- Relative **Band levels**
 - Rel. to average level
 - test frequency response consistency
- Max. **Impulsive Distortion Ratio (IDR)**
 - Abnormal noise and distortion
- Max. **Total Harmonic Distortion (THD)**
 - relative to average level
- Relative **modulated noise**
 - Presence of air leakage and port noise

The following results are based on measurement with a multitone stimulus:

- **Total SPL**
 - Sensitivity and maximum SPL
- **Relative multitone distortion (rel. MD)**
 - Distortion fingerprint
- **Total multi-tone distortion ratio (TMDR)**
- (Mean amplitude compression)

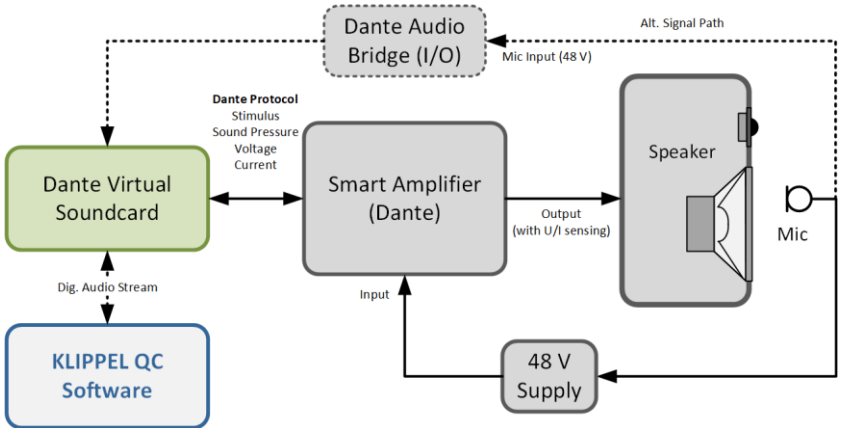
Electrical & Mechanical Parameters	<ul style="list-style-type: none"> • Minimum impedance and R_e <ul style="list-style-type: none"> ○ Short circuit or open loop • Thiele/Small parameters (subset) including vented box parameters¹⁾ <ul style="list-style-type: none"> ○ f_s, Q_{ts} (detect driver issues) ○ f_b, Q_b (detect port issues) • Voice coil offset^{1) 2)} • Stiffness asymmetry^{1) 2)} <p><i>Note: The T/S parameter measurement is only applicable for passive DUTs with single transducers accessible without passive crossover.</i></p> <p>¹⁾ may be applied for DUTs with passive crossover with restricted frequency range</p> <p>²⁾ testing at large-signal level required (high SPL!)</p>
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1.4 Principle

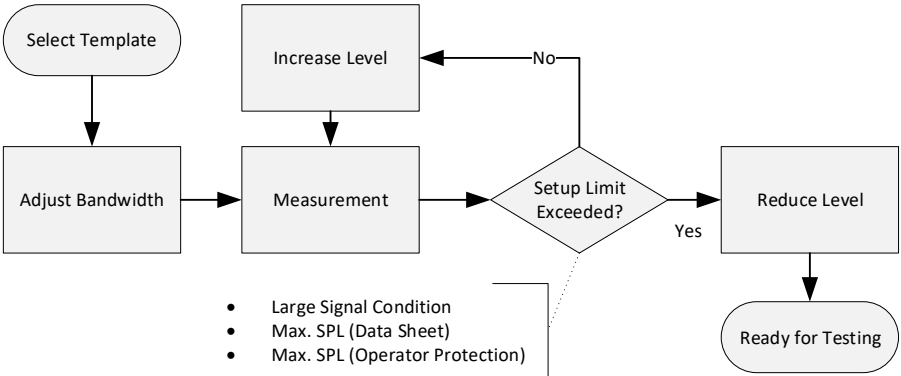
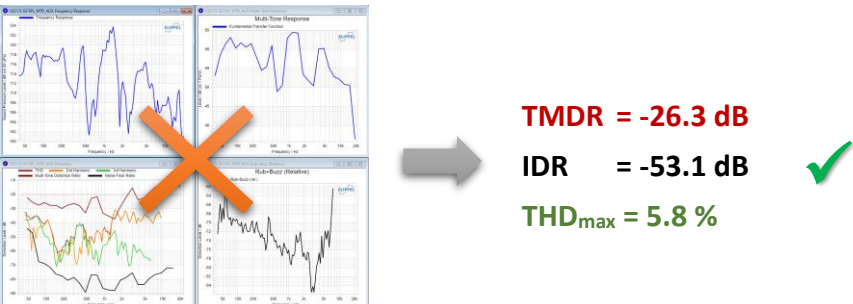
Test Operation	<p>A single speaker test performed by the operator consists of the following steps</p> <p>1 – Preparation</p> <p>The first step includes preparing the device under test (DUT), positioning the microphones, connecting all the necessary cables, and selecting the correct test sequence depending on the DUT model type.</p> <p>2 – Measurement</p> <p>Next, the automated test sequence is run. Different test signals excite the DUT and the recorded responses are processed to yield result metrics and eventually a set of specific test parameters.</p> <p>3 – Result check and defect diagnostics</p> <p>The result parameters are tested against PASS/FAIL and grade limits. The test verdict is displayed to the operator and the result data is stored.</p> <p>In case of a failed test, diagnostics tools can be used to locate the defect and analyze the root cause.</p>
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PASS

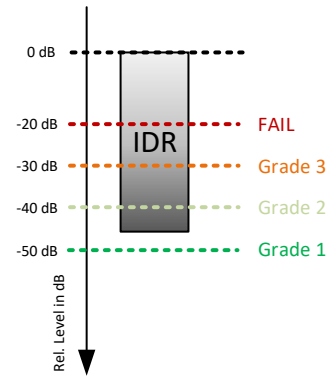
Grade 3	
Full Band - Frequency Response	
Full Band - Average Level	
Full Band - Rel. Level 100-4000 Hz	
Full Band - Rel. Level 4000-10000 Hz	
Full Band - THD	Grade 2
Full Band - Rub+Buzz (rel.)	
Full Band - IDR	Grade 3
Full Band - MODulation	
Full Band - 3DL - Spectrogram	
Full Band - Fundamental	
Full Band - Relative Multi-Tone Distortion	
Full Band - Total MD Ratio	

Smart Amplifier as Test Frontend	<p>As an alternative to a dedicated electro-acoustic analyzer such as <i>KLIPPEL Analyzer 3</i>, this application note is working with 3rd party devices (amplifier, converter) enabled with <i>Dante®</i> audio networking technology.</p>  <p>The <i>KLIPPEL QC Stand-alone Software</i> streams the test signals to the amplifier via <i>Dante Virtual Soundcard</i> and receives the captured microphone, voltage and current signal streams in return.</p>
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Efficient Test Sequence Setup	<p>This application note suggests efficient strategies to get started with testing your speakers quickly:</p> <ul style="list-style-type: none"> • Dedicated test sequence templates for different speaker topologies • Stepped, rule-based setting of bandwidth and levels (see schematic below)
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	<ul style="list-style-type: none"> • Fixed set of reduced, but comprehensive metrics • Universal limit concept based on relative metrics and grades  <p>The setup limits depend on three major threshold conditions (see Results for more information about the tested parameters):</p> <ul style="list-style-type: none"> • Large signal condition (relative distortion thresholds) <ul style="list-style-type: none"> ○ THD > -20 dB (chirp) ○ IDR > -26 dB (chirp) ○ TMDR > -20 dB (multi-tone) • Max. SPL (data sheet) <ul style="list-style-type: none"> ○ Rated maximum sound pressure handling capability of speaker model (apply safety headroom of at least 10 dB) • Max. SPL (operator protection) <ul style="list-style-type: none"> ○ Assumed annoyance threshold: 100 dB SPL + headroom related to hearing → typically 120 dB SPL <p>There may be further restrictions related to</p> <ul style="list-style-type: none"> • Microphone clipping (will be indicated by error message) • Amplifier output clipping • In powered speakers: avoid clipping by any means and make sure that limiters and other protection systems are not activated
<p>Meaningful Metrics</p>	<p>The goal of quality assurance is to provide critical and meaningful test parameters to ensure consistent quality and specification sheet compliance as far as applicable. However, primary metrics such as frequency response or absolute distortion vs. frequency are often too complex, difficult to interpret, or too sensitive towards ambient conditions and microphone placement.</p>  <p>Therefore, this application mainly relies on</p> <ul style="list-style-type: none"> • Single-value number metrics: <ul style="list-style-type: none"> ○ reflect the most important quality parameters (abnormal distortion, overall distortion, frequency response consistency) ○ much simpler handling compared to curve data • Relative metrics <ul style="list-style-type: none"> ○ allow testing independent of the actual SPL value ○ simplify comparison between different DUTs (device under test) ○ insensitive towards reflections and microphone placement ○ ease limit settings

<p><i>Note: curve results are still valuable for setup and diagnostics but no limits are applied</i></p>	
<p>Smart Limit Setting</p>	<p>In QC testing, the PASS/FAIL verdict is typically based on narrow, relative tolerance limits which are derived from reference measurements (e.g., <i>Golden DUTs</i>) or statistics. This approach is not suitable when no dedicated reference units are available or test conditions are varying too much.</p> <p>Therefore, this application note mainly applies absolute (stand-alone) limits applied to the above-mentioned relative metrics. This combination is very powerful and flexible. However, this approach is not applicable to all result parameters.</p>











1.5 Quick Start Guide

<p>Overview</p>	<p>Follow this guide to get started most efficiently. There are three phases:</p> <ul style="list-style-type: none"> • Initial setup of a test system – performed once per test site • Setup of test sequences – performed once per speaker model • Actual testing of individual speakers – on demand
<p>Initial Setup</p> 	<ol style="list-style-type: none"> 1) Pick a test scenario according to your requirements and constraints (<i>Test Scenarios</i>) 2) Read the <i>Requirements</i> section and make sure to have all required hard- and software components on site 3) Prepare the <i>Test Rack and Patch Field</i> or something equivalent (cables, adaptors) 4) Prepare your laptop or PC and perform <i>Software Setup</i> 5) Now you can configure and calibrate the Dante amplifier (<i>Amplifier Setup</i>) using TN17 6) Set up your microphone(s) (<i>Microphone Setup</i>)
<p>Test Sequence Setup</p> 	<ol style="list-style-type: none"> 1) Pick a speaker model; place and connect a representative unit (see <i>Device Under Test (DUT)</i>) 2) Select a suitable template according to the topology (<i>Creating a Test Sequence</i>) 3) Verify/modify global settings (<i>Control Task Settings, Signal Routing</i>) 4) Adjust frequency range of chirp and multi-tone signal according to rated frequency range 5) Adjust test level of impedance test step (<i>Impedance (IMP) Task Settings</i>) 6) Find large signal test level for acoustical tests according to <i>Efficient Test Sequence Setup</i> (also see <i>Sound Pressure (SPL) Task Settings, Multitone Distortion (MTD) Task Settings</i>) 7) Create limits (see Limits and Grading) 8) Perform <i>Trial Run</i> 9) Modify limits, if necessary 10) Test more units for verification
<p>Testing</p> 	<ol style="list-style-type: none"> 1) <i>Select Test</i> sequence (e.g., using bar code) 2) <i>Prepare DUT</i> 3) (Perform self-test, check noise floor) 4) <i>Start the Test</i> 5) <i>Check Results</i> 6) In case of FAIL or low grade, perform <i>Manual Diagnostics</i> 7) Create service report


2 Requirements


2.1 Hardware	
Dante® Amplifier	<p>The main requirement for this application is an audio-over-IP amplifier with integrated voltage and current sensing that supports <i>Dante</i> audio networking protocol. The suggested product is the Powersoft MEZZO 602 AD installation amplifier that provides the following features:</p> <ul style="list-style-type: none"> ○ <i>Dante</i> interface ○ 2 powered outputs, 2 balanced inputs ○ voltage, current sensing* ○ ethernet switch ○ output power: <ul style="list-style-type: none"> ○ 4x 150W @2-8 Ω ○ 1x 400W @4Ω, 1x600W @8 Ω  <p style="text-align: center;"><i>MEZZO 604 AD</i></p> <p>An alternative model is the MEZZO 604 AD providing 4 powered outputs for multi-channel testing. However, impedance measurement will be restricted to max. two channels.</p> <p>Note: It is currently not recommended to test impedance simultaneously on multiple channels. Test sequentially instead (default configuration in all test templates).</p> <p><i>*Powersoft Mezzo currently only provides four Dante return channels that can be configured via Armonia Plus control software. Therefore, impedance testing is only assignable for one speaker channel at a time, assuming that the remaining two channels are used for the microphone signals. Use additional interfaces for the microphones (see below) to allow for two independent speaker channels with impedance sensing.</i></p>
Dante® Audio Bridge/Converter (opt.)	<p>The suggested smart amplifier acts as a compact all-in-one-frontend for testing passive speakers. However, for multi-channel applications, the available Dante return channels are limited. Also, testing self-powered speakers will need balanced outputs. An advantage of Dante audio network is that it is highly scalable and additional devices such as can be added to the test setup, easily.</p> <p>For measuring self-powered loudspeakers, an analog, symmetric line output is required to provide the stimulus signal. A digital-analog converter for Dante audio such as <i>AVIO Analog Output Adapter 0x1</i> by Audinate is recommended.</p> <p>For operation, the adaptor requires power over ethernet (PoE) from a separate PoE injector, which easily can be daisy-chained with the <i>MEZZO</i>:</p> <p><i>PC → MEZZO → PoE injector → Dante-XLR adaptor</i></p>  <p style="text-align: center;"><i>DA0x1</i></p> <p>A more flexible solution for capturing multiple test microphones are Dante converters with integrated 48 V supply such as <i>SYNQ DBT-44</i> or <i>Neutrik NA2-IO-DPRO</i> that can be used in parallel to the <i>Powersoft Mezzo</i> amp.</p> 
PC	<p>A Windows PC is required to operate the KLIPPEL software. A laptop or touch PC is suitable for this application. See separate document <i>KLIPPEL PC Requirements</i> (see References) for further information. An internal sound card or <i>Bluetooth®</i> radio is highly recommended for diagnostics using a microphone and distortion signal playback.</p>

<p>Microphone</p>	<p>A phantom-powered, low noise measurement microphone with sufficient max SPL handling is required for accurate, sensitive and reproducible testing.</p> <p>The Earthworks M23 (Item No. 2400-700) is a very suitable and cost-efficient choice that can be used for all purposes addressed here.</p> <p>Additional equipment for hand-held measurement is recommended (see Further Accessories).</p>	 <p>M23</p>
<p>Phantom Power Supply</p>	<p>When using the <i>Mezzo</i> amplifier without any additional Dante converters that provide dedicated microphone inputs, an external 48 V phantom power supply with symmetrical XLR in- and output is required, such as Mackie M48.</p>	
<p>Microphone Calibrator</p>	<p>Although most suggested test parameters are using a relative scale, a microphone calibrator such as GRAS 42 AG (Item No. 2400-023) is recommended to ensure that SPL limits are monitored correctly. Also, the test setup can be put into operation very easily using a calibrator since the input signal chain is calibrated efficiently into the digital domain with just one measurement.</p>	
<p>Mobile Rack Mount</p>	<p>To put together all required components listed in this section, a mobile 19-inch rack mount with at least 2 RU is highly recommended.</p>	
<p>Patch Field, Adaptors, Cables</p>	<p>In order to adapt the in- and outputs of the amplifier connectors (terminal strip) to commonly used connectors such as speakON and XLR and others (depending on the DUT manufacturer), customized cables and adaptors are required. It is recommended to provide all external connections including USB charging, ethernet and XLR in- and output connectors via a custom patch field for quick plug-and-play capability. Further Information can be found in section Test Rack and Patch Field.</p>	
<p>Optional QC System Accessories</p>	<p>Manual Sweep Controller (Item No. 2800-005)</p> <p>For a quick and easy way to control the frequency and voltage in manual sweep mode, KLIPPEL provides a dedicated 3d controller with intuitive and ergonomic handling. Refer to <i>QC Manual</i> for more information.</p> <p>Temperature & Humidity Sensor (Item No. 2800-011)</p> <p>Changing climate conditions between seasons in non-controlled environments can have significant impact on the DUT behavior and thus the result data may vary. This optional sensor provides automatic temperature and humidity monitoring with every test for traceability.</p> <p>QR/Barcode Scanner (Item No. 2800-004)</p> <p>A <i>QR/Barcode Scanner</i> is recommended to scan the DUT serial number label for the purpose of traceability and for selecting the correct test sequence automatically. This also helps to exclude any potential mistakes by the operator to choose the wrong test.</p>	  

Further Accessories	<p>A microphone pistol grip shock mount (e.g., <i>Rode PG2R</i>) in combination with a quick coupler grip (e.g., <i>Gravity MS QC 1B</i>) is highly recommended when performing handheld tests or manual diagnostics measurements. Also add a microphone stand for non-hand-held testing,</p> <p>in combination with insulated Bluetooth-enabled headphones (e.g., <i>ISOtunes LINK EN352</i>) that provide both hearing protection and playback capabilities for the microphone signal or the isolated defect distortion at a safe level.</p>	 
Optional Radio Link	<p>A radio link for the wireless headphones can ease the handling. For this purpose, any existing radio link may be used (e.g., <i>Bluetooth®</i> wireless technology for the headphone link).</p>	
<h2>2.2 Software</h2>		
KLIPPEL QC Software	<p>This application note will be based on QC Stand-alone Software version (Item No. 4006-001). The base framework license does not include any test tasks. A USB license dongle, the dB-Lab framework software as well as the QC Start test management software are included.</p> <p><i>Please note that QC Stand-alone software licenses can be obtained as usual with unlimited access or via the new subscription model. Please contact KLIPPEL for more information.</i></p>	
Mandatory Modules	<ul style="list-style-type: none"> • QC SPL - <i>Sound Pressure Level</i> task (Item No. 4000-263) – chirp-based acoustic testing • QC IMP – <i>Impedance</i> task (Item No. 4000-262) – impedance and T/S parameters • QC MTD – <i>Multi-tone Distortion</i> task (Item No. 4000-003) multi-tone fundamental and distortion measurement 	
Optional Modules	<ul style="list-style-type: none"> • QC SYN – <i>External Synchronization</i> add-on (Item No. 1001-107) – synchronize digital audio (delay compensation) • QC ALD – <i>Air Leak Detection</i> task (Item No. 4000-240) – testing air noise caused by transducer or enclosure leakage and irregular vented box port noise • QC MSC – <i>Motor + Suspension Check</i> task (Item No. 4000-230) – fast measurement of nonlinear driver parameters like voice coil offset and suspension asymmetry 	
Amplifier Control Software (Armonia +)	<p>For configuring the amplifier's routing and <i>Dante</i> channel assignment, usually, manufacturer-specific software must be used. For <i>Powersoft Mezzo</i>, Klippel provides a settings file that can be loaded via Powersoft Armonia +.</p> <p>Please refer to <i>TN 17 - Setting up Dante & Powersoft Mezzo for QC Stand-alone</i> for more information.</p>	
Dante® Control and Virtual Soundcard	<p>The KLIPPEL QC Software requires a digital playback and capture audio device to stream the stimulus and response signals played and captured by the amplifier and other Dante converters. For <i>Dante</i> audio networking technology, there is a dedicated Virtual Soundcard that can be purchased from the manufacturer's website or from KLIPPEL (Item No. 1000-725) providing an <i>ASIO</i> driver which is highly suitable for operation with KLIPPEL QC.</p> <p>The Dante Control software is required to setup up the signal routing between the devices in the <i>Dante</i> network.</p> <p>Please refer to <i>TN 17 - Setting up Dante & Powersoft Mezzo for QC Stand-alone</i> for more information.</p>	

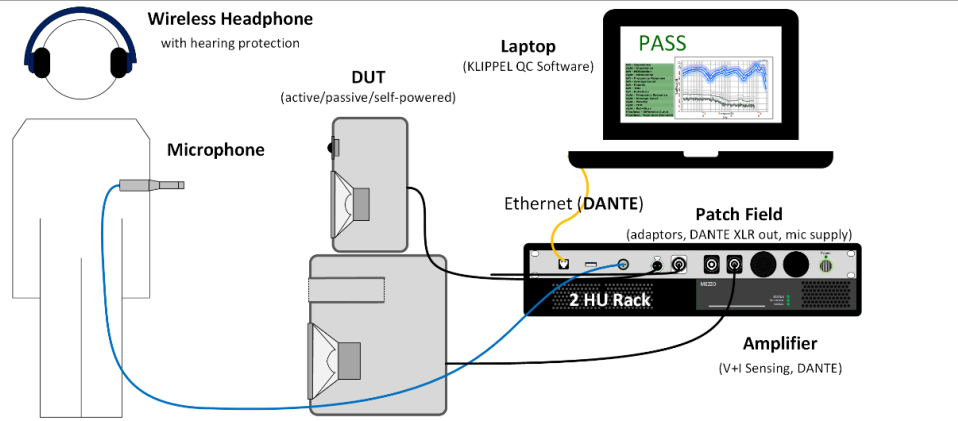
2.3 Test Enclosure

<p>General Remarks</p>	<p>An optional semi-open test enclosure provides major benefits over testing in free air. First of all, it provides a controlled and reproducible mounting and acoustic environment. Furthermore, ambient noise disturbance is attenuated and thus defects can be identified with better sensitivity. The sound attenuation also allows testing at more critical levels (> 100 dB SPL) while keeping harmful peak SPL and annoyance at mid and high frequencies low for all staff members.</p> <p>The following acoustical effects should be considered when constructing a test enclosure.</p> <ul style="list-style-type: none"> • Room modes (standing waves) • First reflections • Rattling/parasitical vibration →important <p>For this test concept, mainly the last-mentioned point is important. Strict guidelines are not useful, but in the following paragraphs are some practical remarks.</p>	 <p><i>Test enclosure at LTI music</i></p>
<p>Stability</p>	<p>First, it is crucial to have stiff and stable walls without any loose parts inside the enclosure to avoid any rattling or parasitical vibrations as good as possible. Especially subwoofer operation can trigger vibration when driven at high SPL which can be misinterpreted as defect symptoms (<i>Rub&Buzz</i>).</p>	
<p>Dimensioning</p>	<p>The open side of the box must provide a sufficiently sized opening (width and height) to allow direct radiation of the largest speakers in stock.</p> <p>To avoid compromising the performance for small and mid-size speakers it can be reasonable to exclude large-size subwoofers and test them in free air instead.</p> <p>More information about how to dimension the volume and other aspects of test enclosures are given in the application note <i>Test Enclosure for QC</i> (AN46).</p>	
<p>Sound Insulation</p>	<p>Furthermore, sound insulation is a main advantage to lower the test signal SPL outside the enclosure and attenuate ambient noise disturbance. With an open enclosure, insulation is naturally compromised, especially at low frequencies. However, for mid and high frequencies that are radiated with a higher directivity, significant attenuation can be achieved. A high wall thickness and mass (the higher the better), as well as acoustical treatment (absorbers) on the inner walls, are desirable.</p> <p>There is a full guide on <i>How to Measure Box Attenuation?</i> in the <i>QC Manual</i>.</p>	
<p>Sound Absorption</p>	<p>In order to attenuate wall reflection conditions for mid and high frequencies, sound absorber material such as acoustic foam can be installed inside the enclosure. This can help lower the first reflections, room modes and noise level inside the test box. The required thickness of the absorber depends on the material and desired minimum frequency to be treated and can usually be determined by checking the data sheet.</p>	
<h3>2.4 Environment</h3>		
<p>Noise Management</p>	<p>In terms of noise there are two major problems when testing:</p> <ul style="list-style-type: none"> • External noise disturbing the test • Noise emitted by the DUT during the test <p>As mentioned in the previous section, a test enclosure is recommended in general. However, since this is not applicable in all cases, some aspects need to be considered.</p>	
<p>Ambient Noise Disturbance</p>	<p>The test strategy is designed to be robust against sporadic external noise disturbance as far as possible. However, a sufficiently high <i>Signal-to-Noise-Ratio</i> is required for</p>	

	<p>acoustical defect testing. Placing the test station as far away from major noise sources as possible helps lower the noise floor within the test environment. Loud impulsive noise sources (e.g., forklifts) corrupting the measured data can be critical, when persistent. However, the system handles sporadic disturbance through measurement repetitions of FAIL steps for verification.</p> <p>Note: the normal <i>ambient noise detection</i> or the advanced <i>Production Noise Immunity (PNI)</i> add-on for the QC SPL task are not applicable for the suggested test method since the ambient noise handling is based on a dedicated ambient microphone and can only be used in combination with <u>reference DUT based limits</u> which is avoided here for the sake of simplicity, robustness and flexibility.</p>
<p>Test Noise and Hearing Protection</p>	<p>When running speaker tests at critical, application-like sound pressure levels, the staff needs to be protected to avoid hearing damage and annoyance. To test maximum SPL output and detect level-dependent defects reliably, the volume rises to levels beyond the permission of occupational safeties from many countries.</p> <p>As mentioned above, a test box can reduce the emitted test noise. Additionally, ensure that the operator and other staff members close by wear hearing protection. This is especially important during diagnostics near/in front of the DUT in presence of high SPL signals (e.g., sound insulating headphones).</p> <p> In any case, it is mandatory to wear certified hearing protection close to the test site to avoid hearing damage. We recommend an overall SPL limit of 120 dB that should be considered during test setup phase assuming 20 dB attenuation.</p>
<p>Climate Conditions</p>	<p>Changes in DUT and air temperature, as well as humidity, can affect the DUT behavior and thus the test result parameters. Therefore, it is required to define reasonably wide test limits and use robust metrics (e.g., relative parameters) to account for the fluctuating climate over the year. This is considered by the suggested test concept.</p> <p>If possible, controlling the temperature in the stock and the test enclosure is recommended to reduce this influence. Also, it is recommended to avoid testing speakers after being transported in very hot (> 35°C) or very cold (< 5°C) conditions.</p>

3 Hardware Setup

<h4>3.1 Test Scenarios</h4>	
<p>Scalability</p>	<p>Although this application note suggests a very particular test approach and setup, it leaves room for scalability, depending on the requirements, capabilities of the actual use case. As an example, three setup levels are introduced in this section. All scenarios are based on the same test rack and mainly differ in terms of periphery.</p> <p>For general hardware requirements and necessary components, refer to Requirements section.</p>
<p>Basic Test Setup</p>	<p>The most basic and at the same time mobile setup is shown in the scheme below.</p>



This setup incorporates one hand-held microphone and the standard test rack according to *Test Rack and Patch Field*. No dedicated test stand or test box is assumed available in this scenario. The test environment does not provide any specific characteristics; there may be uncontrolled noise sources and people standing nearby. The operator and other staff members are required to wear hearing protection.

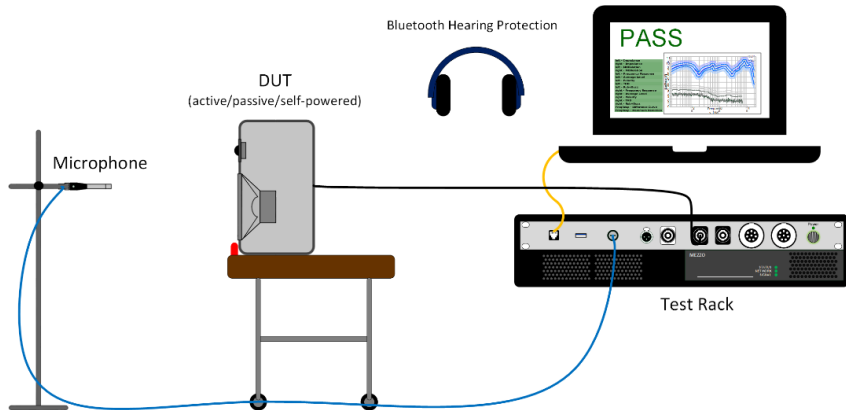
Advantages:

- Cost efficient
- Compact and highly mobile
- Quality control anywhere (e.g., before loading the truck or before rigging)
- Suitable for large DUTs (subwoofers)

Restrictions:

- Limited max. test level (wear hearing protection) – test level may not be sufficiently critical for defect detection
- Poor ambient noise attenuation (high noise floor) – poor sensitivity for defect detection
- Uncontrolled reflections and potential rattling/parasitical vibrations may spoil the results and can lead to misinterpreted defects
- Poor reproducibility

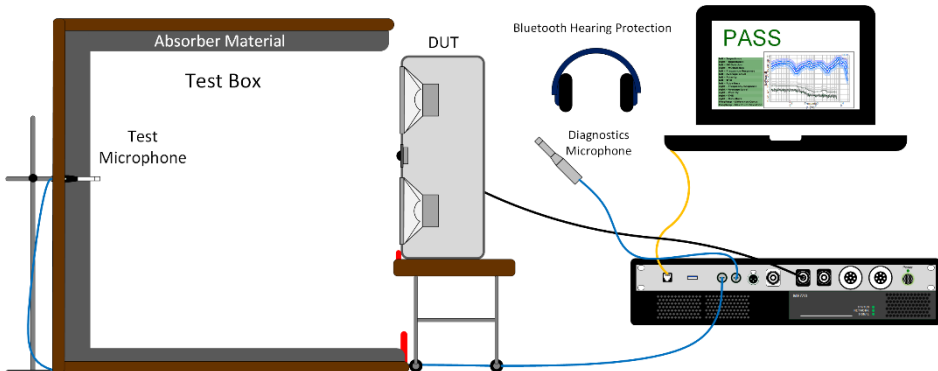
Standard Test Setup



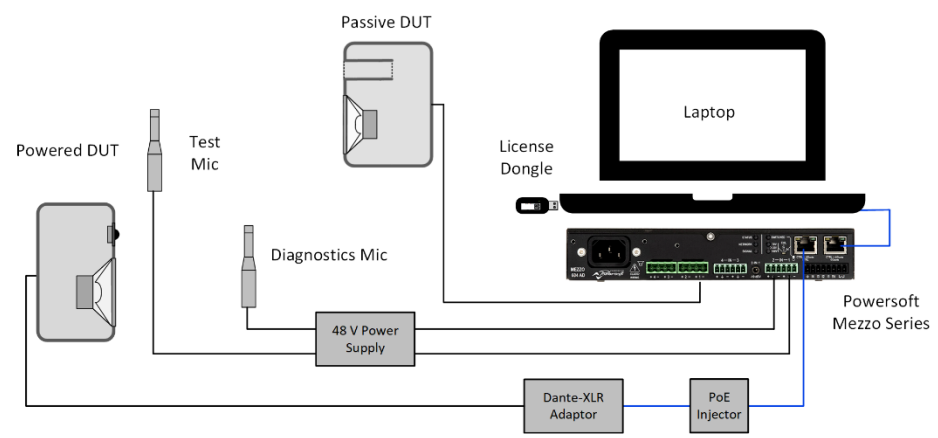
The suggested standard test scenario incorporates all components of the basic setup, but uses dedicated microphone and speaker test stands. The test site can be a dedicated room or location that fulfills some minor requirements such as no presence of loud noise sources in close vicinity and a certain amount of sound insulation (closed room) or at least sufficient distance to other staff members. The operator is located behind the speaker during the test.

Advantages

- Still quite compact and mobile
- Higher test levels possible → more critical
- On-axis data
- Fair reproducibility

	<p>Disadvantages</p> <ul style="list-style-type: none"> • Requires dedicated location and no staff members close by • High noise pollution if located in open space • Uncontrolled reflections and potential rattling/parasitical vibrations may spoil the results and can lead to misinterpreted defects
<p>Recommended Test Setup</p>	<p>This scheme below shows the recommended test setup that incorporates a dedicated, open test box, a DUT trolley and a fixed microphone position.</p>  <p>Additional accessories like a diagnostics microphone and a manual sweep controller simplify diagnostics. For information and requirements related to the enclosure construction, see the Test Enclosure part of the Requirements section.</p> <p>Advantages</p> <ul style="list-style-type: none"> • Highest test levels possible → most critical • Good reproducibility • Attenuation of ambient noise → improved noise floor • Efficient root cause diagnostics <p>Disadvantages</p> <ul style="list-style-type: none"> • Limited mobility of test box • Cost and construction effort • Mostly no on-axis data

3.2 Test Rack and Patch Field

<p>General Routing Scheme</p>	 <p>The schematic above shows the simplified, general routing scheme. It is recommended to integrate the static components and wiring inside a rack while the patch field (see next paragraph) provides all required interfaces to the peripherals, microphones and DUTs.</p>
<p>Patch Field Setup</p>	<p>A patch field is an efficient approach to obtain a mobile, customizable, plug and play test rack.</p> <p>It is recommended to provide the following connectors</p> <ul style="list-style-type: none"> • Connect the PC via Ethernet (RJ45)

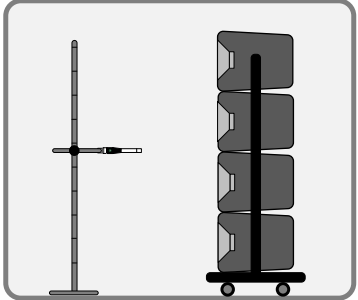
	<ul style="list-style-type: none"> • Connect the microphone(s) to XLR female input(s) (XLR input leads to <i>MEZZO</i> input via 48 V phantom power supply unit) • self-powered DUTs via XLR male out (leads to Dante-XLR adaptor) and optional PowerCON • passive DUTs via SpeakON NL4 (mind actual wiring, connected to the <i>MEZZO</i> outputs) • optional manufacturer specific connectors (e.g., <i>d&b</i>: EP 5, <i>L-Acoustic</i>: CA-COM) • USB sockets via hub for charging headphones or connecting peripherals like <i>manual sweep controller</i> or barcode reader or climate sensor <p>Here is an example sketch that incorporates a subset of the mentioned connectors.</p> <p>Detailed information and component lists for a typical patch bay can be provided on request.</p>
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3.3 Amplifier Setup

Configuration	<p>Before the amplifier’s in- and output channels can be assigned in the Dante routing matrix, the internal routing and configuration needs to be configured. The process is explained in detail in section Powersoft Armonia + Setup of <i>TN 17 - Setting up Dante & Powersoft Mezzo for QC Stand-alone</i> section <i>Calibration</i> for detailed instructions.</p>
Calibration	<p>Any amplifier connected via <i>Dante</i> audio network can be operated right away from the QC software as soon as routing is established. However, both in- and output channels will only be available as digital channels without any information about actual voltages applied to the outputs. While the microphone input path can be calibrated directly using a microphone calibrator, the output channels require specific considerations.</p> <p>For detailed instructions refer to section Calibration of <i>TN 17 - Setting up Dante & Powersoft Mezzo for QC Stand-alone</i> section <i>Calibration</i> for detailed instructions. Please follow the instructions in section <i>Software Setup</i> first.</p>

3.4 Microphone Setup

Test Microphone	<p>The primary microphone facing the DUT’s main radiation axis is the most important sensor for the QC test. In the basic test scenario, there is only one handheld microphone which is also used for diagnostics.</p> <p>Compared to most quality control test scenarios, accurate microphone placement is not required for the suggested testing approach. However, for frequency response consistency testing (band levels), placing the microphone close to the main radiation axis is beneficial to avoid false rejects due to HF directivity.</p> <p>For testing large or curved DUT stacks (e.g., line array dolly) it is recommended to have the microphone at least on-axis between two elements for consistency and comparability reasons.</p> <p>For testing defects like Rub&Buzz and air noise, testing in close proximity ensures the best sensitivity. Therefore, the microphone should be placed within a radius similar to the largest dimension of the DUT, if applicable.</p>
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<p>Considerations for Array Stacks</p>	<p>For stacked line array elements frequent height adjustments of the microphone for each measurement shall be avoided when using a microphone stand.</p> <p>As a compromise, the microphone should be aligned on the axis between two elements.</p> <p>However, this still means that purely off-axis results at different angles are obtained. Consequently, band limits need to be widened, while defect detection may be compromised for the outermost units.</p>	
<p>Diagnostics Microphone</p>	<p>A hand-held microphone is useful for defect localization and root cause analysis right at the DUT that failed the test. For this purpose, either the main test microphone or a dedicated (potentially cheaper) additional microphone is provided in combination with a <i>pistol grip</i> for safe and stable use.</p> <p>Also, refer to the Manual Diagnostics part of the section.</p>	
<p>Calibration</p>	<p>The microphone sensitivity can be measured and calibrated simply using a microphone calibrator. If none is available, the factory sensitivity given in the data-sheet can be used. However, in this case, the amplifier’s signal inputs must be set up and calibrated as analog inputs.</p> <p>Follow the information given in <i>TN 17 - Setting up Dante & Powersoft Mezzo for QC Stand-alone</i> section <i>Calibration</i> for detailed instructions.</p>	

3.5 Device Under Test (DUT)

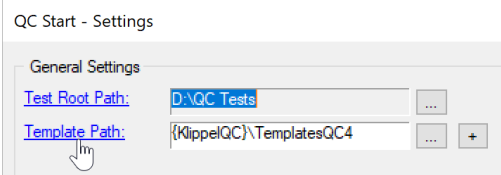
<p>General Remarks</p>	<p>This application note is focused on the quality measurement of the loudspeaker types listed in Test Objects. Both self-powered and passive DUTs can be tested; individually on the floor, on a trolley or stacked in arrays on transport dollies as described in more detail below.</p> <p>The present test concept in general assumes that only one speaker unit is tested at a time and switching is performed manually.</p> <p>It is assumed that manufacturer-specific connectors are adapted using dedicated cables or adaptors mounted in the test rack’s patch field.</p>
<p>Self-powered DUTs</p>	<p>For testing self-powered DUTs, only acoustical tests can be performed. Use the <i>Dante-XLR</i> interface to connect the DUT. Make sure that all tests of the same speaker type are performed with consistent settings (DSP, input gain, ...). Signal processing (especially compressors and limiters) should be deactivated as far as possible.</p>
<p>Active DUTs</p>	<p>The term “active DUT” shall be used for passive speakers with individually accessible frequency ways that rely on external crossovers (e.g., via system amplifier). The speaker inputs shall be exclusively connected to the powered test amplifier’s output channels.</p> <p>To test the full frequency band at one, multiple test steps with differing output routing are required. In this case, more than one output of the amplifier must be used.</p> <p><i>Note that for Powersoft Mezzo currently only one output channel supports electrical (impedance) testing due to limited Dante return channels. It is recommended to test the lowest available frequency channel in this case.</i></p>
<p>Passive DUTs</p>	<p>Passive DUTs are referred to as speakers that only provide one frequency band or have a built-in crossover. The speaker inputs shall be exclusively connected to the powered test amplifier’s output channels.</p> <p>Electrical testing is limited to impedance magnitude testing in this case. However, T/S and non-linear parameters can be determined for the lowest frequency channel in some cases by restricting the fitting frequency range.</p>

Avoid Rattling	Measuring line array stacks directly on the transport dolly is desirable since it reduces mounting effort and simplifies handling drastically. However, the test conditions are not fully appropriate since the high SPL during the test can excite vibration in any loose parts such as grid plates and bolts for connecting array elements. The resulting rattling can be misinterpreted as a loudspeaker defect. In doubt, check for parasitic vibration using Manual Diagnostics and try to remove or fix those parts using tape.
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4 Software Setup

<h3>4.1 General Remarks</h3>	
	This section contains information about the initial software setup and configuration required when putting the system into operation for the first time.
<h3>4.2 QC Software</h3>	
Installation	<p>Download and install the <i>KLIPPEL QC</i> software via QC Install Guide for operation with 3rd party devices and make sure that the provided software licenses are installed afterwards.</p> <div data-bbox="450 824 999 1126" style="border: 1px solid black; padding: 5px;"> <p>WELCOME</p> <p>This guide helps you to install and configure the Klippel QC System version 7.3.</p> <p>Please select a setup mode to proceed and follow the step-by-step instructions:</p> <ul style="list-style-type: none"> • Standard setup with KLIPPEL Analyzer hardware • Setup without analyzer hardware for QC Remote Configuration or QC Stand-alone operation with 3rd party audio device </div> <p>You may skip the calibration part at this stage since the amplifier and <i>Dante</i> setup need to be configured first.</p>
Feature Libraries	<p>At the end of the setup, you will get the chance to open the Feature Library Selector. Click on the link and activate the Sequence Control add-on since it will be required by the provided templates.</p> <div data-bbox="450 1317 986 1361" style="border: 1px solid gray; padding: 2px;"> Sequence Control <input checked="" type="checkbox"/> </div> <p>You may access Feature Library Selector also via <i>QC Start – Add-Ons</i>.</p>
Additional Tools	<p>At the end of the setup additional tools and drivers can be installed as well. In case you have purchased the Manual Sweep Controller device, install the corresponding software here. You may access the setup any time later via <i>QC Start – Tools – Check Installation</i>.</p>
<h3>4.3 Dante Software Setup</h3>	
Dante Virtual Sound Card and Control	<p>This step is required to make the amplifier's in- and output channels as well as the <i>Dante-XLR</i> adaptor accessible to clients like the <i>QC Software</i> via <i>Dante</i> audio network. Follow the information given in <i>TN 17 - Setting up Dante & Powersoft Mezzo for QC Stand-alone</i> section Dante Networking Setup for instructions.</p>
<h3>4.4 Calibration</h3>	
Playback and Capture Device	<p>For instructions refer to section Calibration of <i>TN 17 - Setting up Dante & Powersoft Mezzo for QC Stand-alone</i> section <i>Calibration</i> for detailed instructions.</p>
Microphone	<p>For instructions refer to section Calibration of <i>TN 17 - Setting up Dante & Powersoft Mezzo for QC Stand-alone</i> section <i>Calibration</i> for detailed instructions.</p>

4.5 Install QC Start Test Templates

Download Data Package	Download and unpack the corresponding data package zip file for this application note from the KLIPPEL Application Note website (column <i>Additional Data</i>).
Install Templates	<p>The Qc Start software comes with a variety of application-specific test sequence templates. However, the templates for this application note are currently delivered separately. Copy the downloaded templates folder and paste it to the templates path accessible via <i>Qc Start – Tools – Settings</i>.</p> 

4.6 QC Start Settings

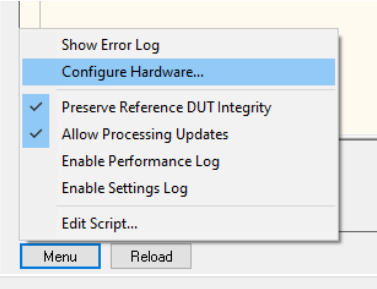
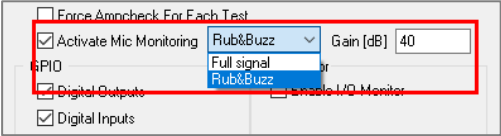
Setting Up Test Selection via Bar Code	<p>You may use the serial number label of your DUT to automatically select the matching test sequence by scanning its bar/QR code. To use this feature, a coherent serial number system for your devices is required where each serial number includes an alphanumeric prefix with fixed number of characters that codes the model type.</p> <p>For more information read <i>How to Use Bar Code Reader Input</i> in the <i>QC Manual</i> section <i>Organizing Projects using QC-Start</i>.</p> <p><i>Please note that a fixed global serial number scheme is required to use this feature.</i></p>
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4.7 Bar Code Reader

	Use your bar code scanner configuration software to set the bar code scanner to work as keyboard wedge (emulates keyboard input). Do not append “Return” to the read serial number string automatically, to avoid that the measurement is started immediately after scanning the label.
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4.8 Headphone Setup

Activate Bluetooth Radio & Pair	In case you are using hearing protection headphones with a built-in <i>Bluetooth</i> link, activate the <i>Bluetooth</i> radio on your host PC or laptop and pair the device.
Set Windows Playback Device	<p>Since the playback feature of the QC software implicitly uses the Windows <i>default playback device</i>, make sure that the paired headphones are selected. Set volume to medium level for the start.</p> <p>In case you are using wired headphones, just select the corresponding output of your built-in or external sound card as default playback device.</p>
Activating Mic Monitoring	<p>For an intuitive diagnostic using the microphone similar to a stethoscope probe, the microphone monitoring feature should be activated to be able to listen to the microphone signal as well as filtered distortion.</p> <p>This setting is individual for each test sequence. After creating a test (see Test Sequence), log in and perform the following settings.</p>

- Opening *Menu / Configure Hardware...* in the property page
 
- Activate *Mic Monitoring* for either the *Full Signal* or the *Rub&Buzz* filtered signal
 - It is recommended to use *Rub&Buzz* since it suppresses the main test signal and makes it easier to hear and locate defects
 - Note: *Rub&Buzz* usually needs a gain boost to make it audible; also use *Windows* system volume to adjust the playback level
- The response signal of any measurement is now played back via the *Windows* default playback device

Find more information in section *Live-Monitoring of Microphone Signal* of the *QC User Manual*

5 Test Sequence Setup

5.1 Overview

The setup and configuration of the test step sequence is the most important step when setting up a test for a new speaker type. Section *Principle* explains the basic concept used in this application note to meet the goals of simplicity, robustness and versatility. For getting started, it is highly recommended to work with the test sequence templates provided with this application note and modify as few settings as necessary. However, the most important setup parameters are explained in this section for reference.

5.2 Creating a Test Sequence

Using a Template

To create your own test, you may either start from scratch or choose a provided template according to your DUT (recommended).

The following base templates will be created for this Application Note:


passive	active (no crossover)	self-powered
Full-range Speaker	2-way Speaker	Full-range Speaker
Subwoofer	3-way Speaker	Subwoofer
Line Array		Line Array

Alternatively, choose from the other more general templates in the *System* category.


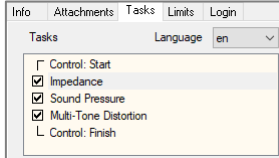
Note: The provided templates are dedicated for common scenarios to get a starting point for your sequence. It is always necessary to adjust settings according to your setup, DUT and requirements.

For using a template

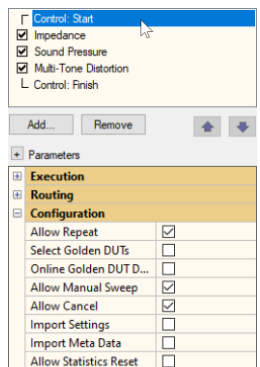
- Make sure that you have installed the application specific templates (see [Install QC Start Test Templates](#))

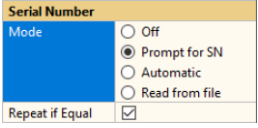
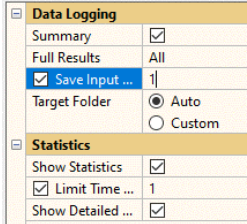
	<ul style="list-style-type: none"> • Start <i>QC Start – Engineer</i> • Select <i>Test - Create New Test...</i> • Choose the appropriate DUT type in the <i>PA + Stage</i> template category • Choose a suitable name: make sure to follow your global naming scheme for barcode-based test selection or type in the name of the manufacturer and the particular model • In <i>Subfolder</i> line you can choose whether you want to store the test sequence in sub-folder of your test root folder for better organization • Finish with <i>OK</i> • Optional: With every created test <i>QC Start</i> will create a folder which comes with a HTML file “<i>testinfo.html</i>” that can be customized with your company logo, a product photos and operator instruction (refer to <i>QC User Manual</i> section <i>How to Add Test Instructions</i>) • Press the <i>Measure</i> button to login or use <i>View</i> to adjust playback and capture device first (not required for application-specific templates based on Dante) 
<p>Start from Scratch</p>	<p>You can also choose to start from scratch without any presets using the <i>Empty Test</i> template.</p> <p><i>Note: This requires advanced knowledge in electro-acoustical measurement and is recommended only for experienced users.</i></p>
<p>Check Playback & Capture Device Settings</p>	<p>Before proceeding with modifying individual test settings, make sure both the global and the local signal routing are correct, as described in section Configuration of QC Operation of <i>TN 17 - Setting up Dante & Powersoft Mezzo for QC Stand-alone</i> section <i>Calibration</i>.</p>

5.3 The Test Sequence

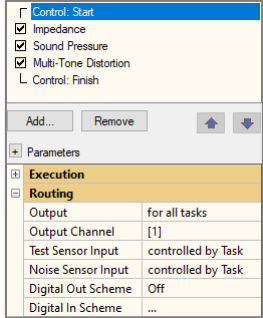
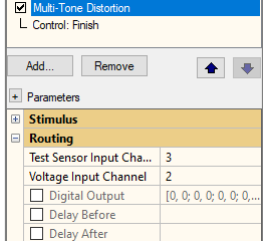
	<ul style="list-style-type: none"> • In <i>Qc Start – Engineer</i>, select a test and click <i>Measure</i> • In most base templates, three steps (<i>tasks</i>) are included: <ul style="list-style-type: none"> ○ <i>Sound Pressure</i> ○ <i>Impedance</i> (only for passive) ○ <i>Multi-tone Distortion</i> • Other test steps like <i>Air Leak Detection</i> or <i>Motor+Suspension Check</i> may be present or added • The properties window is where the tasks and test limits can be configured. Access with the  button or [Alt] + [Return] • Go to the <i>Tasks</i> tab and click on the step in the task sequence that you want to adjust. 	
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5.4 Control Task Settings

<p>Control Panel Setup</p>	<p>In <i>Control:Start</i> you can adjust important settings for the operator interface such as activating serial number input and configuring the available buttons on the <i>Control Panel</i>.</p> <ul style="list-style-type: none"> • <i>Prompt for SN</i> should always be activated while the <i>Configuration</i> settings may be adjusted according to the requirements. • <i>Allow Manual Sweep</i> should always be active in order to allow the operator to activate a sine tone generator for diagnostics 	
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<p>Serial Number Input</p>	<p>A coherent, global serial number system DUTs is crucial for data analysis and traceability. Therefore, make sure to have serial number input activated in every test sequence. This adds a serial number input field for the operator that can be used together with a bar code scanner.</p>	 <p>The screenshot shows the 'Serial Number' settings. The 'Mode' is set to 'Prompt for SN'. Other options include 'Off', 'Automatic', and 'Read from file'. The 'Repeat if Equal' checkbox is checked.</p>
<p>Data Logging</p>	<p>In <i>Control:Finish</i>, make sure that data logging is activated for each individual test sequence.</p> <ul style="list-style-type: none"> • <i>Full Results</i> is mandatory for “lossless” logging of all results and settings and import into the statistics module. • <i>Summary</i> is an optional simple log file for overview. • <i>Save Input Signals</i> allows storing the recorded sensor responses as wave files which are highly valuable for diagnostics, subjective evaluation and can even be used for reprocessing the result with different analysis settings. 	 <p>The screenshot shows 'Data Logging' and 'Statistics' settings. Under 'Data Logging', 'Summary' and 'Full Results' are checked. 'Save Input Signals' is checked with a file name '1'. Under 'Statistics', 'Show Statistics', 'Limit Time ...' (set to 1), and 'Show Detailed ...' are checked.</p>

5.5 Signal Routing

<p>Channel Assignment</p>	<p>Signal routing (in- and output channels) can be set both globally for the complete test sequence or individually for each step. Assuming that you have followed the given instruction for <i>Dante</i> routing setup in the previous sections, you can start right away with the given routing in the provided templates.</p> <p>The following channel assignment for <i>Dante Virtual Soundcard</i> is assumed.</p> <p>Outputs</p> <ul style="list-style-type: none"> • Channel 1 → amplifier output 1 • Channel 2 → <i>Dante</i>-XLR output 1 <p>Inputs</p> <ul style="list-style-type: none"> • Channel 1 → measured voltage @ amplifier output ch. 1 • Channel 2 → measured current @ amplifier output ch. 1 • Channel 3 → test microphone @ amplifier input ch. 1 • Channel 4 → diagnostics microphone @ amplifier input ch. 1 (if available) <p><i>Note that voltage and current input channels cannot be set globally.</i></p>	
<p>Global Routing</p>	<p>The global routing is located in <i>Control:Start</i>. Set fixed channels for outputs and inputs for the whole sequence or those <i>controlled by task</i>.</p> <p><i>Note: At least one setting must be controlled by task, otherwise the routing parameters will be hidden in the task.</i></p>	 <p>The screenshot shows the 'Global Routing' settings. Under 'Control: Start', 'Impedance', 'Sound Pressure', and 'Multi-Tone Distortion' are checked. The 'Routing' section shows 'Output' for all tasks, 'Output Channel' [1], 'Test Sensor Input' controlled by task, 'Noise Sensor Input' controlled by task, 'Digital Out Scheme' Off, and 'Digital In Scheme' ...</p>
<p>Task Routing</p>	<p>The local routing section in the test tasks only needs to be adjusted, if it requires a voltage or current sensor signal (e.g., <i>Impedance</i> task) or if the global routing is set to <i>controlled by task</i>.</p> <p>Also, additional delays before or after the test can be specified here (e.g., to account for settling or decay effects).</p> <p><i>In a reverberant environment, a delay of at least 0.5 s is recommended before the Sound Pressure task to avoid leakage of the previous test response decay (affects Rub&Buzz test)</i></p>	 <p>The screenshot shows the 'Task Routing' settings. Under 'Multi-Tone Distortion', 'Control: Finish' is checked. The 'Routing' section shows 'Test Sensor Input Cha...' 3, 'Voltage Input Channel' 2, and options for 'Digital Output', 'Delay Before', and 'Delay After'.</p>

5.6 Sound Pressure (SPL) Task Settings

	<p>Most defects with acoustic symptoms can be detected by the <i>Sound Pressure</i> task, since it covers the most important parameters like frequency response, harmonic and impulsive distortion based on continuous sweep measurement. This is why most the templates include this task. If you do not use a template, make sure to implement the SPL task first.</p> <p><i>Please refer to the Sound Pressure (SPL) section in the QC Manual for a detailed explanation of all the task properties.</i></p>										
<p>Stimulus Level / Voltage</p>	<p>Depending on the calibration state of your playback device (see Amplifier Setup), you can set the test signal level either as an RMS voltage or as a digital level in dBFS</p> <table border="1" data-bbox="1040 528 1393 645"> <thead> <tr> <th colspan="2">Stimulus</th> </tr> </thead> <tbody> <tr> <td>Start</td> <td>20</td> </tr> <tr> <td>Stop</td> <td>20000</td> </tr> <tr> <td>Time</td> <td>1.4</td> </tr> <tr> <td>Stimulus Level</td> <td>-60</td> </tr> </tbody> </table> <p>This is one of the most critical settings since it defines the SPL output and affects if and how distortion mechanisms and mechanical defects are triggered (high pressure or displacement required).</p> <p>For a critical test, it is recommended to test at typical application sound pressure levels. However, this is hardly possible without a dedicated “boom room”. Therefore, step up the stimulus level until one of the conditions mentioned in section Efficient Test Sequence Setup is reached.</p> <p><i>During the setup phase, you may deactivate other tasks in the sequence to skip measurement by using the checkboxes next to each step in Property Page – Tasks</i></p>	Stimulus		Start	20	Stop	20000	Time	1.4	Stimulus Level	-60
Stimulus											
Start	20										
Stop	20000										
Time	1.4										
Stimulus Level	-60										
<p>Frequency Range (Start, Stop)</p>	<p>The sweep frequency range is the second most important stimulus setting.</p> <p>In a low-level pre-measurement, define the frequency range via the pass-band over a 10 dB SPL decay below the <i>Average Level</i>. (<i>mid-high speakers: default < 20 kHz, sub-woofer: default < 500 Hz</i>)</p>										
<p>Results (Measurements)</p>	<p>In parameter group <i>Measurements</i> you can activate/deactivate individual test result parameters.</p> <p>Recommended are:</p> <ul style="list-style-type: none"> • Frequency Response • Average Level • Band Levels (type: rel. to level) • THD (type: rel. to level) • Rub&Buzz (type: rel. to level) and IDR • MOD_{rel} (ALD license required) <p><i>During limit setup, you can define, whether a result metric is tested against limits or not. Therefore, you may activate more parameters for diagnostics without testing them.</i></p>										
<p>Result Frequencies (Processing)</p>	<p>To adjust the result curve resolution, you can set the <i>Result Frequencies</i> between 3 and 24 points per octave. Using a low resolution is helpful to reduce the complexity and impact of narrow-band acoustical effects.</p> <p>Recommendation: R40 (12 pts/oct)</p> <p><i>For defect detection (Rub&Buzz), no information is lost when using a low resolution, since always the distortion peak of the corresponding interval will be displayed.</i></p>										
<p>Response Normalization (Processing)</p>	<p>This feature allows displaying the <i>Frequency Response</i> relative to the <i>Average Level</i> to monitor consistency instead of absolute SPL.</p> <p><i>This option is a pure display mode which is tied to the absolute frequency response and therefore not an individual test result. However, it is required for Band Levels – Type: Relative.</i></p>										
<p>Average & Band Level Range (Processing)</p>	<p><i>Average Level – Frequencies</i> adjusts the bandwidth of <i>Average Level</i> calculation. Set the DUT’s pass band here or set no range if the stimulus is already restricted to the pass band.</p>										

	<p><i>Band Levels</i> are useful for testing the frequency band consistency of multi-way speakers (e.g., LF, MF, HF), especially when using <i>Relative (normalized)</i> type. Limit Setting and interpretation is much simpler than for full frequency response.</p> <table border="1" data-bbox="448 297 778 383"> <tr> <td>Response - Normalize</td> <td>Average Level</td> </tr> <tr> <td>Average Level - Frequencies</td> <td>[40, 15000]</td> </tr> <tr> <td>Band Levels - Type</td> <td>Relative (normalized)</td> </tr> <tr> <td>Band Levels - Frequencies</td> <td>[40, 1500; 1500, 15000]</td> </tr> </table> <p>See the <i>Band Levels</i> section in the <i>QC Manual</i> for more information.</p>	Response - Normalize	Average Level	Average Level - Frequencies	[40, 15000]	Band Levels - Type	Relative (normalized)	Band Levels - Frequencies	[40, 1500; 1500, 15000]				
Response - Normalize	Average Level												
Average Level - Frequencies	[40, 15000]												
Band Levels - Type	Relative (normalized)												
Band Levels - Frequencies	[40, 1500; 1500, 15000]												
<p>Distortion Settings (Processing)</p>	<p>For the present test concept, it is mandatory to compute total harmonic distortion (THD), as well as <i>Rub&Buzz</i> distortion relative to the <i>Average Level</i> for simple interpretation, comparability and limit setting. Therefore, select <i>Harmonics – Type and Rub & Buzz - Type: Relative to level</i> (dB).</p> <table border="1" data-bbox="1102 443 1393 577"> <tr> <td>Harmonics - Type</td> <td>dB (Relative to level)</td> </tr> <tr> <td>Harmonics - Smooth...</td> <td></td> </tr> <tr> <td>RBz - Highpass</td> <td>10</td> </tr> <tr> <td>RBz - Min Frequency</td> <td></td> </tr> <tr> <td>RBz - Type</td> <td>Peak (ID)</td> </tr> <tr> <td>RBz - Mode</td> <td>dB (Relative to level)</td> </tr> </table>	Harmonics - Type	dB (Relative to level)	Harmonics - Smooth...		RBz - Highpass	10	RBz - Min Frequency		RBz - Type	Peak (ID)	RBz - Mode	dB (Relative to level)
Harmonics - Type	dB (Relative to level)												
Harmonics - Smooth...													
RBz - Highpass	10												
RBz - Min Frequency													
RBz - Type	Peak (ID)												
RBz - Mode	dB (Relative to level)												
<p>5.7 Impedance (IMP) Task Settings</p>													
<p>Impedance Task (IMP)</p>	<p>The <i>Impedance (IMP)</i> task is mainly dedicated to testing the impedance magnitude vs. frequency as well as DC (or minimum) resistance. This works for any passive system topology.</p> <p>Additionally, linear <i>Thiele/Small (T/S)</i> provides a high diagnostic value since even vented box parameters (port resonance) can be tested.</p> <p><i>Note: Thiele/Small Parameter calculation will fail if crossovers are involved but limiting the upper fitting frequency range can help in this case (see below).</i></p>												
<p>Stimulus Level / Voltage</p>	<p>The impedance measurement is typically a “small signal” test performed at low amplitudes. However, for quality control, ideal small signal conditions are not mandatory. A sufficient signal-to-noise ratio is more important to prevent “noisy” impedance magnitude results.</p> <p>A multi-tone distortion+noise level below -20 dB relative to the fundamental component is recommended.</p> <p><i>For further directions, refer to the QC Manual section Optimizing Performance.</i></p>												
<p>Frequency Range (Start, Stop)</p>	<p>The frequency range for the impedance test is not directly related to the <i>Operating Frequency Range</i> given in the DUT data sheet. Start with the template range (usually 5 Hz to 10 kHz) which is suitable in most cases. The <i>Start</i> frequency may be decreased for Subwoofers in case warnings are displayed or raised (min. 500 Hz) for pure HF units.</p>												
<p>Results (Measurements)</p>	<p>In property group <i>Measurements</i>, you can activate/deactivate individual test result parameters.</p> <p>Recommended are:</p> <ul style="list-style-type: none"> • Re or Impedance Values (Minimum Impedance) <p><i>These parameters require absolute limits that depend on the speaker type and can be based on the data sheet.</i></p> <p>Optionally, activate</p> <ul style="list-style-type: none"> • Impedance Magnitude • Current (N+D) – check loose contacts and SNR <p>That should be used without limits.</p> <p>When direct transducer access is available (or range is adjusted – see Max. Fitting Frequency) you may activate the following T/S parameters</p> <ul style="list-style-type: none"> • Resonance Frequency (fs) • Quality Factor (Qts) <p>and in case of vented box principle</p> <ul style="list-style-type: none"> • fb, Qb <p><i>Note that these are not relative parameters. Therefore, limits cannot be set universally and must be set for each speaker type individually.</i></p>												
<p>DUT Type (Processing)</p>	<p>With this parameter you can select the topology of the tested speaker. This is mandatory for T/S parameter measurement. Use <i>Resistive</i> when testing only impedance magnitude and <i>Re, Driver</i> when testing drive units in free air or mounted in a non-vented enclosure. For vented speaker systems use <i>Driver in Vented Box</i>.</p>												

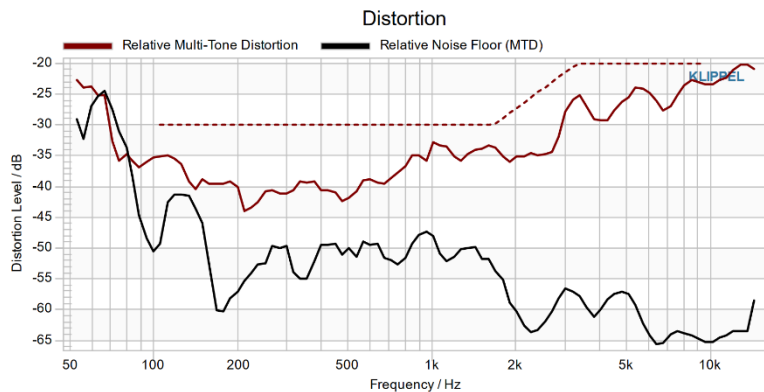
Max. Fitting Frequency	Testing T/S parameters of multi-way speakers is generally difficult because the underlying model only describes a single drive unit mounted in a box. However, in many cases, it is possible to isolate the LF unit (including the vented box parameters) by restricting analysis to the low frequency band (below crossover frequency).	Processing	
		Smoothing	12
		DUT Type	Driver in Vented Box
		Inductance Model	LR-2
		Mech. Calibration	off
		Max. Fitting Frequency	500
		Impedance Values	...

5.8 Multitone Distortion (MTD) Task Settings

Multitone Distortion Task	In contrast to chirp test signals (such as SPL Task), multi-tone signals trigger all distortion mechanisms including harmonic (HD), intermodulation (IMD) and irregular distortion (Rub&Buzz). Multi-tone distortion provides a comprehensive and realistic distortion “fingerprint” since conditions are similar to music playback. Therefore, the MTD is highly valuable to verify overall audio quality and max SPL handling in quality control. <i>Please refer to the Multitone Distortion (MTD) Manual for a detailed explanation of all the task properties.</i>
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Stimulus Level / Voltage	Setting the stimulus voltage and level for a broad-band multi-tone signal is different to pure sine signals (chirp). In contrast to a pure sine, the crest factor is much higher. This means that the signal peak can be 3 to 4 times higher than the specified RMS voltage. Step up the stimulus level until one of the conditions mentioned in section <i>Efficient Test Sequence Setup</i> is reached. In case you hit the <i>Total Multi-tone Distortion Ratio</i> threshold first, reduce the stimulus level by 6 dB (or halve the voltage, respectively) to obtain the final test amplitude.	Stimulus	
		Min Frequency	10
		Max Frequency	10000
		Time	0.5
		Stimulus Level	-50
		Resolution	12
		Preloop	0.5
		Averaging	2
		<input type="checkbox"/> Level Profile	[10, 0; 500, 0]

Results (Measurements)	For simplified interpretation, benchmarking and easy limit setting, it is good practice to relate the multi-tone distortion band levels to the neighbouring fundamental. This results in the <i>relative MD</i> which can be expressed in percent or equivalently as a relative level in dB (“distance” to fundamental). Due to the different scales, the relative MD is plotted in the <i>Distortion</i> window. The interpretation is similar to <i>THD</i> based on chirp measurement.
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In property parameter group *Results*, you can activate/deactivate individual test result parameters.

Recommended are:

- Fundamental – (e.g., Transfer Function)
- Level
- Multi- Tone Distortion (MD)
- Total MD Ratio
- Noise floor (for SNR)

Processing	<p>In <i>Processing</i> properties, make sure that <i>MD – Type</i> is set to <i>Band Level</i> and <i>MD – Relative</i> is activated. <i>Fundamental – Mode</i> allows to select whether the Fundamental shall be based on the SPL spectrum, frequency response or transfer function. The latter is recommended since it is independent of test level and can indicate compression.</p> <p>The <i>Recording Delay</i> only needs to be set in case no automatic synchronization via <i>SYN add-on</i> is used (copy from <i>Sound Pressure Task</i>).</p>	<table border="1"> <thead> <tr> <th colspan="2">Processing</th> </tr> </thead> <tbody> <tr> <td>Fundamental - Mode</td> <td>Spectrum</td> </tr> <tr> <td>Fundamental - Smoothing</td> <td>3</td> </tr> <tr> <td>MD, Noise Floor - Smoothing</td> <td></td> </tr> <tr> <td>MD - Type</td> <td>Max. Level</td> </tr> <tr> <td>MD - Relative</td> <td><input checked="" type="checkbox"/></td> </tr> <tr> <td>MD - Unit</td> <td>dB</td> </tr> <tr> <td>Total MD Ratio - Unit</td> <td>%</td> </tr> <tr> <td><input checked="" type="checkbox"/> Recording Delay</td> <td>41</td> </tr> </tbody> </table>	Processing		Fundamental - Mode	Spectrum	Fundamental - Smoothing	3	MD, Noise Floor - Smoothing		MD - Type	Max. Level	MD - Relative	<input checked="" type="checkbox"/>	MD - Unit	dB	Total MD Ratio - Unit	%	<input checked="" type="checkbox"/> Recording Delay	41
Processing																				
Fundamental - Mode	Spectrum																			
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MD - Type	Max. Level																			
MD - Relative	<input checked="" type="checkbox"/>																			
MD - Unit	dB																			
Total MD Ratio - Unit	%																			
<input checked="" type="checkbox"/> Recording Delay	41																			

5.9 Trial Run

	<p>During setup phase, usually one or more test runs are necessary to verify correct settings. After finishing initial settings, run the test sequence using the <i>Start</i> button in the <i>QC Control Panel</i>.</p> <p>During this phase you may deactivate all tasks in the sequence that you are currently not investigating using the checkboxes next to the tasks.</p> <p>Refer to the <i>First Measurement</i> section of the <i>QC Manual</i> for more information about how to create and perform a test.</p>	
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6 Limits and Grading

6.1 Overview

Overview	<p>Defining sensible tolerance limits is crucial for quality control. Therefore, it is just as important as setting up critical test parameters. When setting the limits, there is always the trade-off between</p> <ul style="list-style-type: none"> • having wide and robust tolerances to prevent false alarms and • having tight limits for high-quality standards and best failure detection <p>The latter approach makes sense for very well-controlled environments and a very coherent set of DUTs with very similar characteristics (e.g., in end-of-line testing at the manufacturer site).</p> <p>In rental equipment testing however, the main goal is to detect functional degradation and failure with sufficient sensitivity, while ensuring robustness towards test conditions. Also, false fails shall be prevented since the tolerances must be valid for the full stock of speaker units that may have very different age.</p> <p>There are two main methods for defining limits:</p> <ul style="list-style-type: none"> • stand-alone limits (also known as absolute limits, no reference DUT required) • reference-based limits (tolerance-driven limits, require reference DUT or target value/response) <p>with particular advantages and disadvantages. These methods in this application note mainly rely on universal, stand-alone limits.</p>
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6.2 Stand-alone Limits without Reference Units (Absolute)

Pass/Fail Limits	<p>In contrast to reference-based limits as used in EoL testing, stand-alone limits do not necessarily depend on the particular speaker model or test setup (environment, microphone position), but can be universal and applicable to various different speakers if applied to suitable metrics.</p> <p>This is especially the case when applied to test parameters that are based on relative metrics.</p> <table border="1" data-bbox="414 1998 1348 2042"> <thead> <tr> <th>Result Parameter</th> <th>QC Task</th> <th>Upper Limit</th> <th>Lower Limit</th> <th>Unit</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> </tbody> </table>	Result Parameter	QC Task	Upper Limit	Lower Limit	Unit					
Result Parameter	QC Task	Upper Limit	Lower Limit	Unit							

Rel. Band Levels	SPL	10	-10	dB
THD (rel. to level)	SPL	-14	-	dB
IDR	SPL	-20	-	dB
Rel. MD	MTD	-20	-	dB
TMDR	MTD	-20	-	dB
MOD_{rel}	SPL/ALD	10	-	dB
Min. Impedance*	IMP	150	1.5	Ω
Coil Offset (rel. to peak displacement)	MSC	+20	-20	%
Stiffness Asymmetry	MSC	50	-50	%

*universal baseline limit – may be refined using datasheet nominal impedance – see Reference-based Limits (Relative)

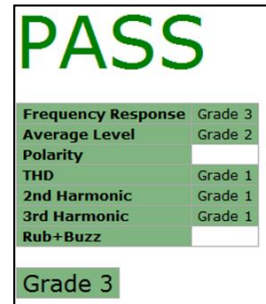
Ensure sufficient signal- or distortion-to-noise ratio (at least 20 dB or 10 dB), respectively. This can be checked based on manual or automatic pre-measurement without having a DUT connected (automatic noise floor measurement only provided by *MTD Task*).

Grading

In addition to the strict PASS/FAIL limits, further tolerances allow defining different quality grades or defect severities. This can help to identify borderline units or early indications of ageing and reliability problems from real defects with severe symptoms.

Example:

- Grade 1 – Perfect
- Grade 2 – OK
- Grade 3 – Borderline
- Grade 4 – Service Required



Up to ten grades can be defined individually for each tested parameter. The overall grade follows the worst (highest number) sub-grade.

Here is a guideline for recommendation for the tested parameters (in conjunction with previously-defined limits).

Result Parameter	Grade 1	Grade 2	Grade 3	Grade 4	Unit
Rel. Band Levels	±4	±6	±8	±10	dB
THD (rel. to level)	-26	-23	-20	-14	dB
IDR	-50	-40	-30	-20	dB
Rel. MD	-35	-30	-25	-20	dB
TMDR	-20	-30	-25	-20	dB
MOD_{rel}	3	6	10	-	dB

Find more information in *QC Manual* section *Grading*.

Note that also background noise or bad microphone placement may degrade the results.

6.3 Reference-based Limits (Relative)

Based on Spec Sheet

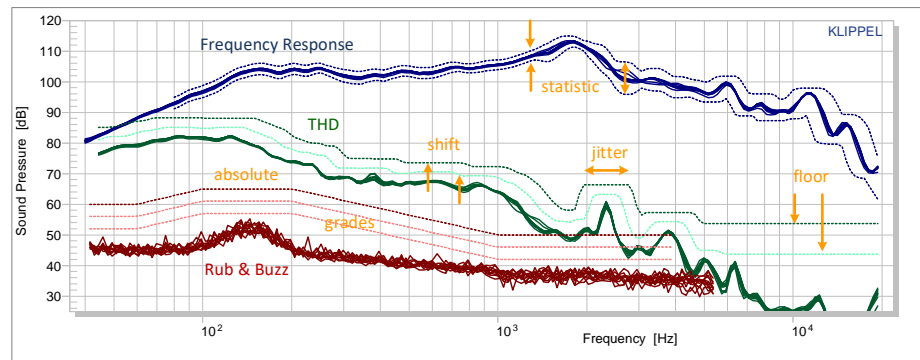
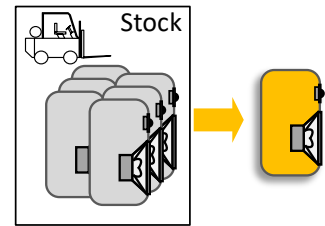
Some parameters such as nominal impedance, frequency range or SPL_{max} should be taken from the manufacturer’s product specification sheet, either for configuring the test signal (max level, bandwidth) or for limit definition by applying a tolerance to the stated values, such as for nominal impedance:
 Min. Impedance: 16 Ω ± 20 %
 Use limit *Calculation Mode - Absolute + Shift* in this case.

Loudspeaker data	
Configuration	Installation specific 2-way compact coaxial loudspeaker
Nominal impedance	16 Ω
Power handling capacity (RMS/peak 10 ms)	60/400 W
Nominal dispersion angle (h x v)	100° conical
Components	5" driver 1" dome tweeter coaxially mounted passive crossover network
Connections	2 x NL4 screw terminal block

Source: www.dbaudio.com

Based on Golden DUT

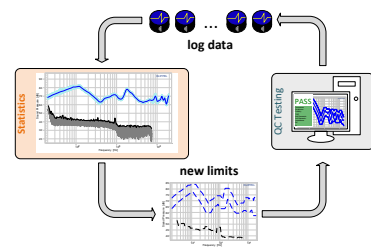
This STAT also provides the opportunity to determine one or multiple “golden” DUTs that best represent the average, automatically. These golden DUTs are used as a representative reference unit for the whole pool and can be used to calibrate environmental influences. Furthermore, golden units can be used for setup and plausibility checks of the test setup.
 Refer to *STAT Manual* section *Detection of Golden Units* for more information.



For more information refer to *QC Manual* section *Limit Calculation* or AN79.

Based on Statistics

Knowing the statistical spread of your complete stock takes out the guess work in limit setting and provides a realistic point of view on the effective parameter variation. This is crucial to set reasonable test limits with sufficient tolerance.
 The *Limit Calculation Mode* of the QC software allows you to measure several reference units and derive shifted limits relative to the average.




The test templates come with recommended, predefined settings but tolerance values or frequency ranges may be adjusted. Find more information in *QC User Manual* section *Limit Calculation*. This is a straightforward approach when the good units are known in advance, but otherwise not very flexible. Therefore, it is recommended to test the full stock in advance for basic statistical analysis and defining suitable limits.

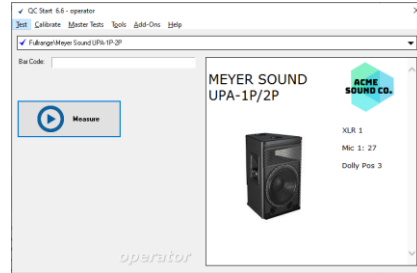
7 Test Operation

7.1 Overview


This part explains the few, simple steps that are required to perform the actual speaker tests once the initial setup was completed.

7.2 Select Test

- 1) Start the QC Start - Operator and **pick the right test** depending according to your speaker model
Alternative: scan the barcode of the DUT if bar code test selection was configured.
- 2) Click the *Measure* button to **open the test**.
- 3) If the test only contains one operation (default), you will be logged in automatically. Otherwise, log in by clicking the  button.
- 4) **Scan the serial number** tag again to fill in the serial number in the *QC Control Panel*. (Attention: make sure that the reader does not append *Return*, otherwise the test is started immediately)

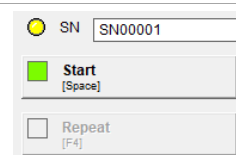


7.3 Prepare DUT

- 5) If the **DUT** is not provided on a dolly, put it **on the test cart** or stand. Subwoofers can be tested directly on the floor.
- 6) **Connect** all necessary power and signal **cables** to the DUT. Note that some DUTs (active) may provide separate LF and HF input (cable assignment).
- 7) If self-powered, **turn on the device**. If volume controls are available, make sure that they are set to a defined default level (e.g., full / 0 dB) and all additional filters (e.g., low-cut) are bypassed.
- 8) Align the **microphone position** horizontally on axis with the HF-driver of the DUT, if possible.
- 9) Make sure to **wear hearing protection** after this point 

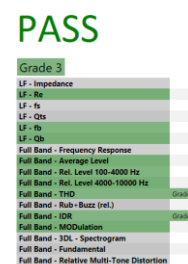
7.4 Start the Test

- 10) Use the **Start** button or press space bar to run the test sequence.



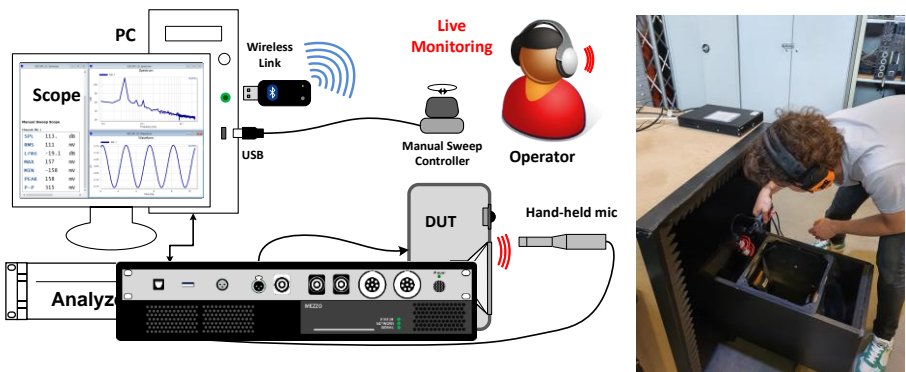
7.5 Check Results

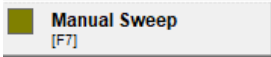
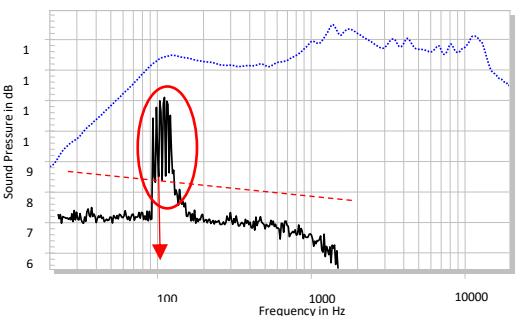
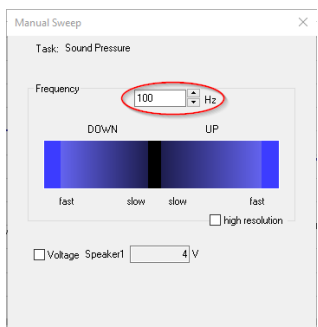
- 11) If all parameters give a **PASS**, you may remove the DUT and go ahead with the next device.
The grey verdicts are related to parameters that are measured but have no limits.
- 12) If one or results give a **FAIL**, you may repeat the measurement twice by pressing the repeat-button [F4-key] to make sure the data was not corrupted by any coincidence like impulsive ambient noise. Also check for trivial errors (cables not connected, wrong microphone position etc.)



	<p><i>Note: the repetition of the failed step can be automated using the Sequence Control Feature library.</i></p> <p>13) If it still gives a FAIL, the device needs a service with extensive troubleshooting (see next section <i>Manual Diagnostics</i>)</p> <p>14) If the DUT has passed, but <i>Grading</i> is activated and the overall grade has a low rank (high number), follow the instruction provided by the engineer.</p>
--	--

7.6 Manual Diagnostics

<p>Preparation</p>	<p>The main tool for diagnostics after a DUT has failed the test is the <i>Manual Sweep</i> feature. It is a straight-forward sine tone generator with a simple analyzer and simultaneous audio playback of the microphone or filtered <i>Rub&Buzz</i> response.</p>  <p>As stated in <i>Hardware Setup</i>, you may use</p> <ul style="list-style-type: none"> • a hand-held microphone and • headphones with hearing protection <p>for this purpose. The optional <i>Manual Sweep Controller</i> eases control of sweep frequency and level but requires a wired USB connection.</p> <p>1) Make sure that the headphones are connected to the PC via cable or wireless link. Also, check that the required output device is selected as the default playback device in <i>Windows Sound</i> settings and muting is deactivated.</p>
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<p>Running Diagnostics</p>	<p>2) Start up a manual sweep by pressing the <i>Manual Sweep</i> button [F7]</p>  <p>3) Pick a striking frequency (e.g., point of maximum in <i>Rub&Buzz</i> curve) in the curve results and adjust the manual sweep frequency to that value</p>   <p>4) Now pick up the microphone and move it closely to the DUT and try to find the origin of irregular noise</p> <p>5) Most potential defects will be audible over the headphone more and more as you get closer to it</p>
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7.7 Typical Problems

Most systematic failures during testing are related to trivial problems. Here is a list of common issues you can check through before continuing with in-depth diagnostics:

- False microphone position (not sufficiently within speaker's main radiation axis)
- Twisted cables and connectors (wrong channel assignment of the DUT)
- Powered DUTs are not switched on or controls are set incorrectly
- Lose connectors
- Parasitic vibrations by the dolly or any loose parts near the measurement place (e.g., forgotten tools, screws)
- Loud and steady ambient noise disturbance

8 Diagnostics

8.1 Typical Defects

Defects come in many shapes and forms with different severity. In many cases the result parameters and violated limits can indicate the root cause, but for complex systems, manual diagnostics as described in section *Running Diagnostics* is often inevitable.

To get an idea, this list shows typical defects and their symptoms:

Transducer

- Damaged surround or punctured membrane → buzzing, air leakage noise
- Damaged windings → lower impedance and sensitivity, impulsive distortion (crackling)
- Thermal overload → lower/higher impedance, low sensitivity
- Bottoming (suspension failure, asymmetry) → impulsive distortion
- Coil rubbing (rocking modes, suspension damage) → impulsive distortion
- Suspension fatigue → harmonic/multi-tone distortion, lower F_s

Enclosure

- Loose joints and screws → air leakage noise, buzzing
- Loose grill → buzzing
- Damaged or occluded port → air noise, altered box resonance (f_b , Q_b)
- Loose parts inside the box → impulsive distortion

Electronics

- Crossover failure → degraded frequency response (band levels)
- Electronic parts degradation or failure → no output, harmonic/multi-tone distortion, reduced SPL output
- Loose connectors → crackling (impulsive distortion), no output

Most defects that cause impulsive distortion and abnormal noise can be classified according to their symptoms. Some cause very reproducible patterns strictly coupled to the input signal (higher order harmonics) while others are only loosely coupled to the transducer vibration (e.g., broad-band air noise).

8.2 Interpreting Results

In this section, some example defects and their correlation to the test result parameters are investigated.

Average and Band Levels

To reduce complexity for testing sensitivity/max SPL and tonal balance, *Band Levels* and *Average Levels* are suitable alternative test parameters to the fundamental frequency response curve. However, both metrics are based on the full response curve (before smoothing) but are much easier to interpret and test.

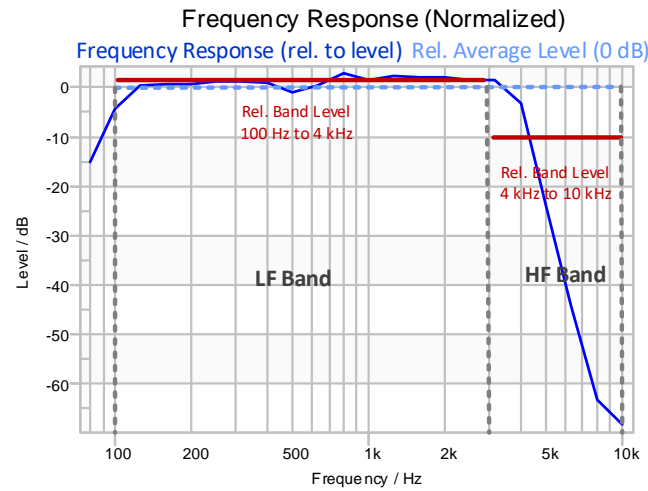
Using default settings, the *Average Level* reflects the mean SPL in the measured or band-limited (optional) frequency range.

In addition to the total level, a custom number of *Band Levels* can be measured to test for individual frequency band failure (e.g., to differentiate woofer from tweeter failure).

Refer to *Average & Band Level Range* for more information about the setup.

Removing the average level from frequency response beforehand yields the relative band levels, which are very useful for testing independent of the overall SPL using universal limits as shown in the example above.

The example below shows an example result of a 2-way speaker with a tweeter failure resulting in a FAIL verdict of the upper band level.



Full Band - Average Level
 Full Band - Rel. Level 100-4000 Hz
 Full Band - Rel. Level 4000-10000 Hz

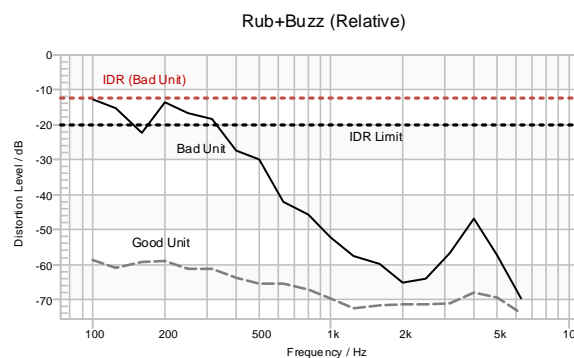
Name	Value	Min Limit	Max Limit	Unit	Description
Average Level	97.7	80.0	120.0	dB (re 20 uPa)	mean level of fundamental frequency response in specified bands
Rel. Level @ 100-4000Hz	0.917	-8.000	20.000	dB	relative level of specified frequency point or band
Rel. Level @ 4000-10000Hz	-10.277	-8.000	20.000	dB	relative level of specified frequency point or band

Impulsive Distortion (Rub & Buzz)

Impulsive Distortion Level (aka *Rub & Buzz*) and *Impulsive Distortion Ratio* (IDR) reflect irregular, impulsive noise and distortion as caused by most defects of the transducer, the enclosure and other irregularities in the playback chain (e.g., brick-wall limiter, signal dropouts).

Relating the distortion SPL to the *Average Level* of the fundamental response gives a strong indication of the severity. Although it cannot be related to audibility, directly, it is possible to set universal limits such as -20 dB to indicate a serious defect, independent of the actual test level or even speaker type.

For straight-forward testing it is sufficient to extract the peak value (*IDR*) during the measurement and the corresponding excitation frequency for diagnostics. The example below indicates a defective woofer in a 2-way speaker (damaged surround).



Full Band - Rub+Buzz (rel.)
 Full Band - IDR Grade -

	<table border="1" data-bbox="451 192 1332 246"> <tr> <td>IDR</td> <td>-12.8</td> <td>-</td> <td>-35.0</td> <td>dB</td> <td>maximum Impulsive Distortion Ratio</td> </tr> <tr> <td>IDR Frequency</td> <td>100.0</td> <td>-</td> <td>-</td> <td>Hz</td> <td>excitation frequency @ max. IDR</td> </tr> </table> <p>Limits should always be verified with at least one approved reference unit for each DUT type to make sure that no false fails are generated due to overly sensitive limits.</p> <p>Since this metric is sensitive towards any external noise disturbance, it is recommended to perform 3 measurement repetitions for a reliable verdict in case of a FAIL.</p> <p><i>Note: Ambient Noise Detection feature of the QC System can only be used with a second ambient microphone and reference-based limits.</i></p>	IDR	-12.8	-	-35.0	dB	maximum Impulsive Distortion Ratio	IDR Frequency	100.0	-	-	Hz	excitation frequency @ max. IDR																								
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<p>Modulation (Air Leakage)</p>	<p>In case an <i>Air Leak Detection (ALD)</i> license is available, you may add the stand-alone test step to the sequence or activate the <i>MODulation</i> result parameter in the SPL task. This parameter indicates turbulent air noise radiated by driver or enclosure leaks.</p> <div data-bbox="1129 501 1396 719" style="float: right;"> </div> <p>MODulation 100%</p> <p>The most important result for flexible testing is the <i>relative MODulation</i> level since it acts as a “leakage indicator” and can be tested with universal limits (0 dB → no symptom, > 10 dB → strong symptoms).</p> <table border="1" data-bbox="619 801 1220 875"> <thead> <tr> <th>Name</th> <th>Value</th> <th>Max Limit</th> <th>Unit</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>MODabs</td> <td>29.4</td> <td>40.2</td> <td>dB</td> <td>Absolute modulated distortion</td> </tr> <tr> <td>MODrel</td> <td>0.0</td> <td>7.5</td> <td>dB</td> <td>Relative modulation distortion</td> </tr> </tbody> </table> <p>The absolute level in contrast reflects the absolute SPL of the leakage noise. It cannot be tested with universal limits.</p> <p><i>Note: also vented box ports generate a certain amount of MODulation. Carefully verify limits with reference speakers.</i></p>	Name	Value	Max Limit	Unit	Description	MODabs	29.4	40.2	dB	Absolute modulated distortion	MODrel	0.0	7.5	dB	Relative modulation distortion																					
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<p>T/S Parameters (Vented Box)</p>	<p>Using linear Thiele/Small parameters, valuable diagnostic information can be generated from the impedance measurement (<i>IMP Task</i>). This includes also vented box parameters such as resonance frequency f_b and Q-factor Q_b.</p> <p>They can be used to identify defective or loose vents or even misplaced damping material blocking the port as shown in the example below.</p> <p>LF - f_b LF - Q_b</p> <table border="1" data-bbox="451 1267 1145 1395"> <thead> <tr> <th>Name</th> <th>Value</th> <th>Min Limit</th> <th>Max Limit</th> <th>Unit</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>Re</td> <td>6.26</td> <td>4</td> <td>10</td> <td>Ohm</td> <td>electrical voice coil resistance at DC</td> </tr> <tr> <td>fs</td> <td>131.3</td> <td>-</td> <td>-</td> <td>Hz</td> <td>resonance frequency of driver</td> </tr> <tr> <td>Qts</td> <td>0.54</td> <td>-</td> <td>-</td> <td>-</td> <td>total Q-factor of driver</td> </tr> <tr> <td>f_b</td> <td>108.6</td> <td>105.0</td> <td>140.0</td> <td>Hz</td> <td>resonance frequency of vented or passive radiator enclosure</td> </tr> <tr> <td>Q_b</td> <td>5.04</td> <td>6.00</td> <td>15.00</td> <td>-</td> <td>total Q-factor of the acoustic system at f_b</td> </tr> </tbody> </table> <div data-bbox="531 1529 687 1742" style="float: left; margin-right: 20px;"> </div> <div data-bbox="715 1476 1273 1823" style="float: right;"> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-top: 10px;"> <p>T/S Parameters $R_e f_s Q_{ts} f_b Q_b \dots$</p> </div> </div> <p><i>Note: limit setting requires validated reference units or data sheet information (e.g., tuning frequency)</i></p>	Name	Value	Min Limit	Max Limit	Unit	Description	Re	6.26	4	10	Ohm	electrical voice coil resistance at DC	fs	131.3	-	-	Hz	resonance frequency of driver	Qts	0.54	-	-	-	total Q-factor of driver	f_b	108.6	105.0	140.0	Hz	resonance frequency of vented or passive radiator enclosure	Q_b	5.04	6.00	15.00	-	total Q-factor of the acoustic system at f_b
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Manuals	<ul style="list-style-type: none"> • QC User Manual • dB-Lab User Manual • Hardware Manual • MTD User Manual • ALD User Manual • SYN User Manual
Tech Notes	<ul style="list-style-type: none"> • TN 17 - Setting up Dante & Powersoft Mezzo for QC Stand-alone <p>Available on klippel.de.</p>
Application Notes	<ul style="list-style-type: none"> • AN 46 – Test Enclosure for QC • AN 79a – Quality Control of Sound Reinforcement Equipment <p>Available on klippel.de.</p>
Standards	<ul style="list-style-type: none"> • IEC 60268 parts 21/22/23
Workshop	<ul style="list-style-type: none"> • “Quality Assurance of Live Sound Reinforcement Equipment”, R. Werner, AES Vienna 2020
Specifications	<p>Software</p> <ul style="list-style-type: none"> • C3 QC Software • S13 QC – Motor and Suspension Check (MSC) • S18 QC – Air Leak Detection (ALD) • S68 QC – MTD Multitone Task • S32 QC External Synchronization (SYN) <p>Hardware</p> <ul style="list-style-type: none"> • A4 – Microphones • A6 – Accessories for the Klippel Analyzer System <p>Other</p> <ul style="list-style-type: none"> • Klippel PC Requirements • Klippel Amplifier Requirements <p>Available on klippel.de.</p>

Find explanations for symbols at:

<http://www.klippel.de/know-how/literature.html>

Last updated: September 14, 2023

Designs and specifications are subject to change without notice due to modifications or improvements.

